TECHNOLOGY PROFILE: VACUUM-MEDIATED LNAPL FREE PRODUCT RECOVERY/BIOREMEDIATION *(BIOSLURPER)*

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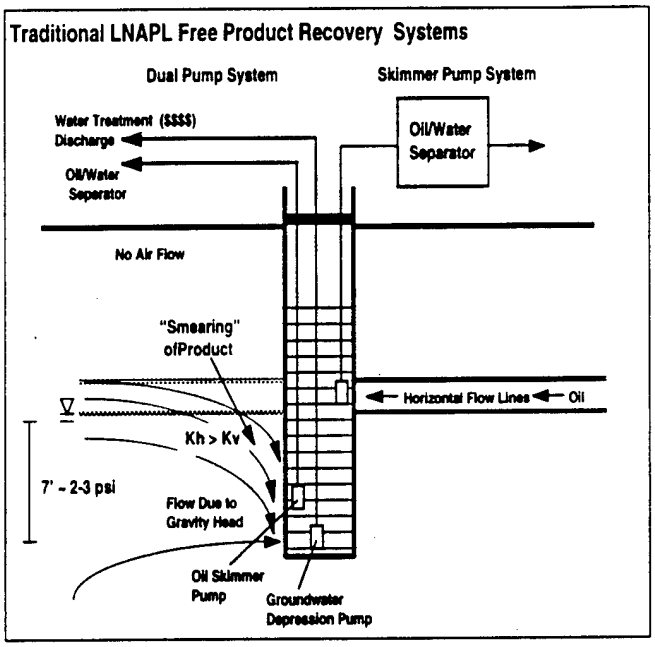
Applicability: LNAPL Free Product "Floating" on the Water Table

Vacuum-mediated Free Product Recovery/ Bioremediation (Bioslurping) is applicable to sites where light nonaqueous phase liquids (LNAPLs) (e.g., petroleum hydrocarbons: gasoline, jet fuels, diesel, heating oils, etc.) form a measurable layer of LNAPL on the water table. All parameters that affect the recoverability of the LNAPLs should be considered in site selection. Major factors include the mass of LNAPL (Is there enough to recover?) and the relative permeability of the subsurface matrix to air, water, and LNAPL. This technology can simultaneously remove LNAPL free product and treat the unsaturated (vadose) zone (via bioventing).

Contingent Technologies: Skimmer and/or "Dual Pump" Product Recovery Systems

Skimmer and/or dual pump systems are traditional free product recovery technologies. Skimmer pump systems place a product recovery pump directly in the LNAPL layer. Air lift and/or mechanical pumps are employed. Dual pump systems utilize a lower ground water pump to depress the water table in an attempt to create a "driving force" for LNAPL recovery at a second skimmer-type pump. Both these systems rely upon gravity as the only driving force. The ground water pumping and treating equipment of dual pump systems dramatically increase remedial capital, permitting, and operations and maintenance costs. Also, "smearing" of LNAPL product occurs upon depression of the water table. In almost all natural settings the horizontal permeability (Kh) is greater than vertical permeability (Kv). Thus, the downward movement of product toward a dual pump recovery system is hindered due to lower vertical permeability. Testing of skimmer and dual pump systems will be conducted for "side to side" comparisons.



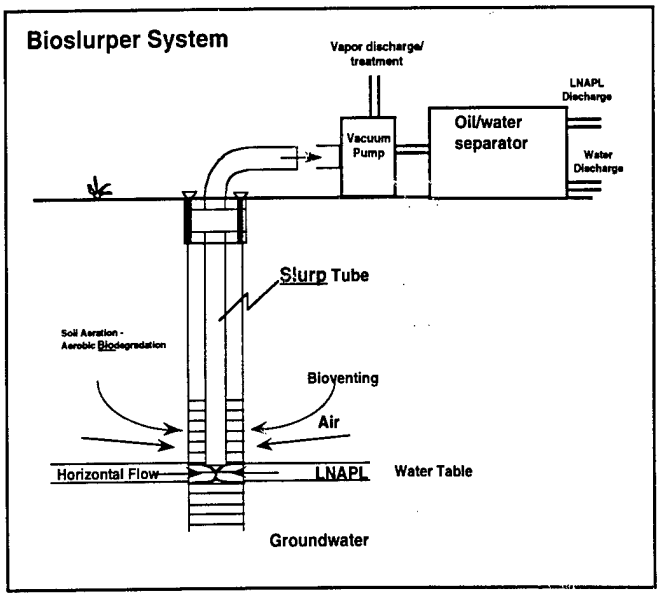
Background: AFCEE Technology Application Approach

The AFCEE Technology Transfer Division (ERT) focuses on critical environmental restoration areas; and evaluates, demonstrates, and applies cost-effective, "off-the-shelf" technical solutions; and promotes technical and regulatory acceptance of the proven solutions. Therefore, in the same fashion that bioventing has been identified and tested as a presumptive remedial solution to petroleum hydrocarbon contamination in the vadose zone, vacuum-mediated pumping or bioslurping has been identified as a strong and cost-effective solution to LNAPL free product contamination. Using an approach similar to the AFCEE Bioventing Initiative (138 sites at 48 military bases), AFCEE/ERT plans to conduct a multiple site application of the bioslurping technology in coordination with the regulatory community. Cost and performance comparisons will be made to traditional reference technologies.

Background: Site-specific Considerations

This initiative will also address proper methods to characterize and estimate the magnitude of the LNAPL plume. This is a critical area, since it is established that there is not a strong correlation between the amount of LNAPL free product detected in monitoring wells and that which is actually present in the formation. Thus, as outlined in the AFCEE Remediation Matrix - Hierarchy of Preferred Alternatives, apparent versus actual studies are to be performed in order to more accurately estimate recoverable free product mass. The most straight-forward apparent vs. actual study is to hand-bail the well and document the recovery of product into the well. If the product continues to recover into the well, then product recovery appears more feasible. Apparent vs. actual procedures will be developed and tested under this initiative and integrated into a "how-to" manual.

Technology Description: Vacuum-mediated Free Product Recovery/ Bioremediation (Bioslurping)



Bioslurping is an approach adapted from the vacuum dewatering industry. A bioslurper system consists of a "slurp" tube that extends into the LNAPL free product layer in the well. Product is drawn into the tube as air flows up the tube toward the vacuum extraction pump. Product is drawn up the tube in the form of a column, slugs, droplets, vapor, and/or a film. Product can be drawn up the tube as a solid column, provided that the product flows into the well fast enough and the depth below the ground surface does not exceed roughly 25 feet below the ground surface. Otherwise, the product is "slurped" up the well through entrainment. Recovery of product is enhanced over conventional methods because as opposed to gravity alone, the vacuum provides a driving force. Product flow proceeds along a horizontal flow path which reduces product entrapment or "smearing" typical of dual pump systems. In addition, as vapor is extracted from the subsurface, oxygen, in the form of air, promotes aerobic biodegradation (a.k.a. Bioventing) throughout the affected vadose zone and capillary fringe. Another advantage is that minimal ground water is extracted which normally increases the costs significantly due to above ground treatment and permitting requirements. The liquid stream extracted from the bioslurper well flows through to the vacuum pump to an oil/water separator and vapor discharge/treatment point. Internal combustion engine systems will be employed at numerous sites as energy conservation equipment. Although different configurations will be evaluated, these systems can serve as a vacuum pump, vapor/ product treatment unit, electrical power generator, "air stripper", and/or water pump. An objective of the AFCEE Bioslurper Initiative will be to develop a configuration that will be as self-sustaining as practical and to minimize the amount of waste requiring further treatment or off-site disposal, unless the recovered product is appropriate for recycling. After product recovery is complete bioslurper systems can be easily reconfigured into full-time bioventing systems to focus remediation on residual vadose zone contamination.

Point of Contact:

Patrick E. Haas
AFCEE/ERT
8001 Arnold Drive
Brooks AFB TX 78235-5357

COM: 210-536-4331
DSN: 240-4331
FAX: 210-536-4330